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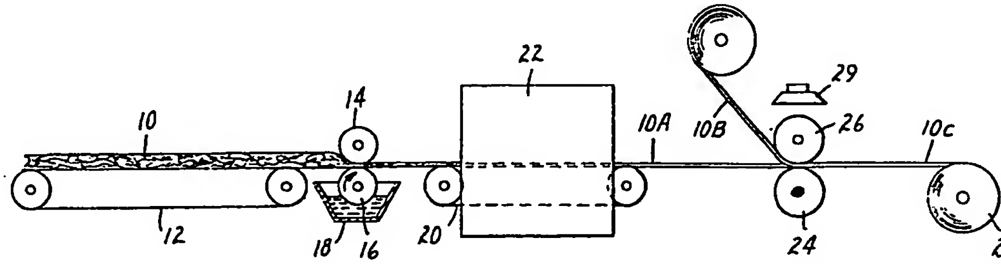

(57) Abstract

The electrical-insulating pressure-sensitive adhesive tape (10C) can be produced by (1) forming a fluffy web (10) of oriented polymeric fibers, (2) simultaneously squeezing and saturating the fluffy web between rolls (14, 16) with a crosslinkable polymeric resin in a volatile vehicle, and (3) heating in an oven (22) to drive off the vehicle. The resultant tape can be produced at a cost comparable to that of paper-backed tapes while possessing tear strength, resistance to heat and electrical-insulating properties comparable to those of more expensive tapes of the prior art.

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ELECTRICAL-INSULATING PRESSURE-SENSITIVE ADHESIVE TAPE AND A PROCESS OF MAKING SAID

Technical Field

The invention relates to an improved backing for electrical-insulating pressure-sensitive adhesive tape.

Background Art

Because of their low cost, kraft and hemp papers have been widely used as backings for electrical-insulating pressure-sensitive adhesive tapes, but paper-backed pressure-sensitive adhesive tapes have inferior tear strength, resistance to heat and electrical insulating properties. Typical paper-backed pressure-sensitive adhesive tapes are disclosed in U.S. Patents No. 2,548,980 and No. 2,733,169. To provide better dielectric and physical strength, a high-strength plastic film may be laminated to a paper backing before applying a pressure-sensitive adhesive coating, but this increases the cost.

Paper-like backings based on polymeric fibers, such as cold-drawn polyester fibers, have provided better electrical insulation, tear strength, and resistance to heat, but heretofore only at substantially increased cost. One such backing, as disclosed in U.S. Patent No. 3,309,260, is made from a randomly-intermingled mixture of cold-drawn and undrawn fibers, the latter fusing under heat and pressure in order to knit the former into a coherent web. Before using that web as a backing for a pressure-sensitive adhesive tape, the web must be unified. For example, an electrical-insulating varnish may be applied or a preformed oriented polyester film may be bonded to the web to unify it for use as a backing for a pressure-sensitive adhesive tape.

Another fibrous backing for pressure-sensitive adhesive tape is shown in U.S. Patent No. 3,562,088. Referring to Fig. 1 of the drawing, a layer of acrylic resin 10 is cast onto a polypropylene film 12, and a carded web of polymeric fibers 14 such as nylon is laid

into the acrylic resin layer. The three layers are hot-calendered between rolls 16 and 20 to provide a non-woven fibrous backing to which a pressure-sensitive adhesive layer 22 may be applied (Fig. 3). This tape should have excellent electrical-insulating and other physical properties, but at substantially increased cost as compared to ordinary paper-backed electrical-insulating tapes.

Disclosure of Invention

The present invention concerns pressure-sensitive adhesive tape which can be produced at a cost comparable to that of ordinary paper-backed pressure-sensitive adhesive tapes while providing tear strength, resistance to heat and electrical-insulating properties comparable to those of the tape of U.S. Patents No. 3,562,088 and 3,309,260.

The novel pressure-sensitive adhesive tape, like that of U.S. Patent No. 3,562,088, has a flexible backing member comprising a resin-bonded web which comprises (a) one or more layers of nonwoven, randomly-intermingled, electrical-insulating, oriented polymeric fibers and (b) a polymeric resin binder. The fibers form a continuous, substantially-uniform network extending to both surfaces of the resin-bonded web and should

have a denier of 1 to 8,
have a softening point of at least 200°C,
remain essentially unchanged after exposure to 130°C for months, and
have a tenacity of at least one gram per denier.

The novel pressure-sensitive adhesive tape differs from that of U.S. Patent No. 3,562,088 in that the polymeric resin binder of its resin-bonded web is a crosslinked polymeric resin which would by itself provide a self-sustaining film

having a tensile strength of at least 0.7 MPa,

being capable of being folded repeatedly upon itself without cracking,

having a dielectric strength of at least 25 volts per micrometer, and

remaining essentially unchanged after exposure to 130°C for months.

The ratio of fibers to resin in the resin-bonded web of the invention is from 1:2 to 6:1. The novel resin-bonded web has a thickness of 25 to 200 micrometers and a tear strength of at least 2 kN/m at a thickness of 75 micrometers. (Test method: TAPPI T 470 os-78). The voids-volume of the novel resin-bonded web is less than 60%, as readily calculated from density, weight and thickness measurements. Accurate thickness measurements can be made by ASTM D645 using a motor-operated micrometer with a 16-mm diameter foot and a 1000-gram nominal dead-weight load.

To make the resin-bonded web of the novel tape, a fluffy web of nonwoven, randomly-intermingled, electrical-insulating fibers is simultaneously squeezed and saturated with a dispersion of a crosslinkable polymeric resin composition in a volatile vehicle. Heat is applied to drive off the vehicle, and sufficient heat and pressure are applied to crosslink the resin and to attain a voids-volume of less than 60%. Above 60%, the resin-bonded web would have inferior internal strength, and if it were coated with a layer of pressure-sensitive adhesive and then wound upon itself in roll form, it might delaminate upon unwinding. Preferably the voids-volume is less than 55% to minimize pin-holes.

Because the heat and pressure under which the resin-bonded web is densified should be applied simultaneously, the crosslinkable polymeric resin composition preferably gels very quickly at high temperatures. Unless the resin begins to gel while still in contact with the surfaces applying that pressure, it would tend to stick to

those surfaces.

A layer of pressure-sensitive adhesive may be applied directly to the resin-bonded web to provide the novel tape. A composite backing member of better dielectric strength may be provided by coating an electrical-insulating resin composition onto one or both faces of the resin-bonded web and drying this to a flexible, tack-free, electrical-insulating state, preferably crosslinked before applying a layer of pressure-sensitive adhesive. This resin coating covers any pin-holes and may comprise the same resin composition as the binder of the resin-bonded web. However, the preferred compositions for the resin coating could not be used as the resin binder. Particularly preferred as the resin coating are the compositions of U.S. Patent No. 3,027,279 (Kurka et al.). The composition of the resin coating may be selected to enhance flame retardancy.

Another means for improving the dielectric strength of the flexible backing member is to densify one or more layers of the resin-bonded web in face-to-face contact with a flexible high-strength, electrical-insulating plastic film to provide a composite backing. The plastic film should

- have a thickness of 10-70 micrometers,
- have a softening point of at least 200°C,
- remain essentially unchanged after exposure to 130°C for months, and
- have a tensile strength in the longitudinal direction of at least 35MPa, and
- have a dielectric strength of at least 100 volts per micrometer.

The resistance to 180° peelback between said backing member and said plastic film should be at least 4 N/100 mm of width.

Each of the aforementioned techniques for improving the dielectric strength significantly increases

the cost of tapes of the invention above that of a paper-backed tape.

A crosslinkable polymeric resin composition which is especially useful as the binder of the resin-bonded web is provided by an acrylic copolymer such as a copolymer of a major proportion of an unbranched or moderately branched alkyl acrylate having 1-8 carbon atoms in the alkyl group and a minor proportion of copolymerizable carboxylic acid such as acrylic acid. The acrylic monomers may be copolymerized with a minor proportion of styrene.

A preferred crosslinking agent for the acrylic copolymers is hexamethoxymethylmelamine. Water-borne dispersions of crosslinkable acrylic copolymer compositions including this crosslinking agent tend to dry quickly at 120°C with very little crosslinking and then to crosslink to a thermoset state very quickly at 175°C and extremely fast at 220°C. Care should be used in selecting agents for emulsifying the dispersions, many of which would provide a significant reduction in electrical-insulating properties. Emulsifying agents should also be selected to avoid corrosive characteristics.

Other useful crosslinkable polymeric binder resins include styrene-butadiene, styrene-butadiene-acrylonitrile, and vinyl acetate copolymers having pendant groups through which they may be crosslinked such as carboxyl groups.

Preferred oriented polymeric fibers for the resin-bonded web of the backing are polyesters, such as polyethylene terephthalate, and nylon polyamides, especially highly aromatic polyamides. Particularly good results have been obtained using blends of polyester and polyamide fibers, since blends have proven to be easier to process and have produced backings of higher strength at a given thickness than have unblended polyester fibers.

It would be difficult to make a resin-bonded web using fibers of less than one denier. Above a denier of

about 8, it would be more difficult to attain the desired voids-volume of less than 60%.

Backings of superior strength have been obtained by bonding reinforcing strands such as continuous glass filaments to the resin-bonded web. Preferably such reinforcing filaments extend substantially the full length of the tape and are located between two layers of fibers comprising the resin-bonded web or between the resin-bonded web and a plastic film.

The Drawing

Fig. 1 schematically illustrates apparatus suitable for making a preferred resin-bonded web for a pressure-sensitive adhesive tape of the invention, and

Fig. 2 is a schematic edge-view of a tape of the invention.

Referring to Fig. 1, nonwoven, randomly-intermingled, electrical-insulating fibers are deposited from a garnett or other carding machine (not shown) as a fluffy web 10 onto an endless carrier 12 which carries it to a pair of rolls 14, 16. The roll 16 rotates in the direction of the arrow to carry from a bath 18 to the nip of the rolls a crosslinkable polymeric resin composition in a volatile vehicle. The saturated fibers are borne by a second endless carrier 20 through an oven 22 to drive off the vehicle, thus providing a dried, handleable web 10A. A second pair of rolls, one of which 24 has a metallic surface while the other 26 is rubber-covered, densify the web 10A and an identical web 10B under heat and pressure to provide a two-layer resin-bonded web 10C which is wound upon itself into roll form at 28. The resin-bonded web 10C may later be unwound and coated with a pressure-sensitive adhesive (this not being shown) to provide a tape of the invention. Aggressive pressure-sensitive adhesives may require the application of a low-adhesion backsize coating to the other face of the tape.

The roll 24 is preferably steel and may be internally heated to provide a surface temperature of about 220-270°C. The other roll preferably is covered with silicone rubber and may be heated both by conduction from the steel roll and by an infrared lamp 29 to provide a surface temperature of about 150-200°C. At these operating temperatures, reasonably fast production rates should be possible since the resin should gel quickly, thus averting sticking.

If the web 10B were replaced by a high-strength, electrical-insulating plastic film 30 having a low-adhesion backsize coating 36, the resin binder of the web 10A would adhesively bond it to the plastic film to provide a composite flexible backing member 32 as illustrated in Fig. 2. A pressure-sensitive adhesive layer 34 is adhered to the other face of the resin-bonded web 10D into which the web 10A has been converted upon being densified under heat and pressure.

Example 1

A continuous fluffy web of drawn polyethylene terephthalate polyester fibers (38 mm long, 1.75 denier, and weighing 13.7 grams per m^2) from a garnett machine was saturated with an aqueous acrylic resin dispersion as shown in Fig. 1. The acrylic resin was a copolymer of a major proportion of n-butyl acrylate and minor proportions of styrene and acrylic acid. The dispersion contained 7.5 parts of hexamethoxymethylmelamine per 100 parts of the acrylic resin. The saturated web was dried in an oven at 120°C and wound up. The dried web weighed 20.4 grams per m^2, had a thickness of 150 micrometers, and its binder resin content was 32% by weight.

Three layers of the dried web were densified face-to-face in a heated steel-roll, silicone-rubber-roll laminator. The surface of the steel roll was heated to 243°C and the surface of the rubber roll to 188°C. The laminating speed was 9 meters per minute, and the nip roll

pressure was 44.7 kg per cm. The resulting resin-bonded web was tough and well bonded and had a thickness of 110 micrometers. The voids-volume was 44%.

One surface of this resin-bonded web was coated with a solution of a pressure-sensitive adhesive (cross-linkable copolymer of 98/2 isooctyl acrylate/acrylic acid) which was dried with heat to a thickness of about 25 micrometers. The finished tape was wound on itself and was later unwound without delaminating the backing or offsetting of the adhesive to the backside, even though there was no low-adhesion backsize coating. Some test properties:

Of the tape (ASTM D 1000):

Breaks at	946 N/100 mm
Elongation	25%
Adhesion to steel	30 N/100 mm
Dielectric strength	1800 volts
Insulation resistance	10^7 megohms

Of the backing (TAPPI T 470 os-78):

Tear strength	11 kN/m

Example 2

A layer of the dried web of Example 1 was densified in face-to-face contact with a 33-micrometer biaxially-oriented polyethylene terephthalate film using the same conditions as in Example 1. The thickness of the resulting composite was 85 micrometers. Its resin-bonded web was well bonded to the film, having a 180° peel value from the film of 0.15 kN/m as run on a Thwing-Albert tensile tester at 305 mm per minute jaw speed.

The web side of this composite was coated with a crosslinkable 94/6 isooctylacrylate/acrylic acid copolymer pressure-sensitive adhesive composition and dried with heat to a thickness of 45 micrometers. Some test properties of the tape:

Breaks at	753 N/100 mm
Elongation	13%
Adhesion to steel	80 N/100 mm
Dielectric strength	5400 volts
Insulation resistance	10^6 megohms

As compared to an identical tape except for omission of the resin-bonded web, the tape of this Example 2 is easier to handle for many applications in that it has more body and does not curl when removed from the roll. It also has much more resistance to elongation and has high puncture resistance. It exhibits excellent resistance to long term aging at 130°C.

Example 3

Two layers of the dried web of Example 1 were densified face-to-face using the same conditions as in Example 1 to provide a resin-bonded web having a voids-volume of 49%. This resin-bonded web was simultaneously coated on both sides with a thermosetting resin composition based on brominated epoxidized polyester and brominated epoxy resin, followed by heating for 15 minutes at 135°C to cure the coatings to a flexible, tack-free, flame-retardant, electrical-insulating state. The resulting composite was smooth and very flexible, having an overall thickness of 110 micrometers. One face of the composite was coated with a solution of a crosslinkable rubber-resin pressure-sensitive adhesive, essentially as disclosed at Example 3 of U.S. Patent No. 3,718,495. After drying with heat to a thickness of 37 micrometers, a low-adhesion backsize coating was applied to the other face. Some test properties:

Of the tape (ASTM D 1000):

Breaks at	805 N/100 mm
Elongation	24%
Adhesion to steel	44 N/100 mm
Dielectric strength	7000 volts
Insulation resistance	10^7 megohms

Of the backing (TAPPI T 470 os-78):

Tear strength	9 kN/m

CLAIMS

1. Electrical-insulating pressure-sensitive adhesive tape comprising a flexible backing member and a pressure-sensitive adhesive layer, said flexible backing member comprising a resin-bonded web which comprises (a) at least one layer of nonwoven, randomly-intermingled, electrical-insulating, oriented polymeric fibers and (b) a polymeric resin binder, which fibers form a continuous, substantially uniform network extending to both surfaces of the resin-bonded web, and

have a denier of 1 to 8,

have a softening point of at least 200°C,

remain essentially unchanged after exposure to 130°C for months, and

have a tenacity of at least one gram per denier;

characterized in that

said polymeric resin binder is a crosslinked polymeric resin which would by itself provide a self-sustaining film which

has a tensile strength of at least 0.7 MPa,

is capable of being folded repeatedly upon itself without cracking,

has a dielectric strength of at least 25 volts per micrometer, and

remains essentially unchanged after exposure to 130°C for months, and

said resin-bonded web having

a ratio of fibers to resin from 1:2 to 6:1,

a thickness of 25 to 200 micrometers, and

a tear strength of at least 2 kN/m at a thickness of 75 micrometers.

2. Pressure-sensitive adhesive tape as defined in claim 1 and further characterized in that there is bonded to the outer face of said backing member a plastic film which

has a thickness of 10-70 micrometers,
has a softening point of at least 200°C,
remains essentially unchanged after exposure to 130°C for months,
has a tensile strength in the longitudinal direction of at least 35 MPa, and
has a dielectric strength of at least 100 volts per micrometer.

3. A pressure-sensitive adhesive tape as defined in claim 1 and further characterized in that there is a coating of a flexible, tack-free, electrical-insulating resin on one or both faces of said resin-bonded web.

4. A pressure-sensitive adhesive tape as defined in claim 1 and further characterized in that there are reinforcing strands bonded to said backing member and extending substantially the full length of the tape.

5. A pressure-sensitive adhesive tape as defined in claim 1 wherein the crosslinked polymeric resin comprises an acrylic copolymer.

6. The method of making an electrical-insulating pressure-sensitive adhesive tape comprising the steps of

(1) forming a fluffy web of non-woven, randomly-intermingled, electrical-insulating, oriented polymeric fibers which

have a denier of 1 to 8,
have a softening point of at least 200°C,
remain essentially unchanged under exposure to 130°C

for months, and

have a tenacity of at least one gram per denier;

(2) simultaneously squeezing and saturating the fluffy web with a dispersion of a crosslinkable polymeric resin in a volatile vehicle, which resin by itself is capable of forming a self-sustaining film which

has a tensile strength of at least 0.7 MPa,

is capable of being folded repeatedly upon itself without cracking,

has a dielectric strength of at least 25 volts per micrometer, and

remains essentially unchanged after exposure to 130°C for months;

(3) then heating to drive off the vehicle to provide a dried handleable web having a ratio of the fibers to the resin from 1:2 to 6:1;

(4) densifying the dried web under heat and pressure to a voids-volume of less than 60% and a thickness of 25-200 micrometers, the heat being sufficient to crosslink the polymeric resin binder to provide a resin-bonded web; and

(5) applying a layer of pressure-sensitive adhesive to the resin-bonded web to provide an electrical-insulating pressure-sensitive adhesive tape.

7. Method as defined in claim 6, in step (4) of which at least two said dried webs are densified face-to-face to provide a multi-layer resin-bonded web.

8. Method as defined in claim 6, in step (4) of which said dried web is densified face-to-face with a high-strength, electrical-insulating plastic film to provide a unified flexible backing member, and in step (5) the pressure-sensitive adhesive layer is applied to the exposed face of the resin-bonded web.

9. Method as defined in claim 6, wherein between steps (4) and (5), an electrical-insulating resin

composition is coated onto at least one face of the resin-bonded member and dried to a flexible, tack-free, electrical-insulating state.

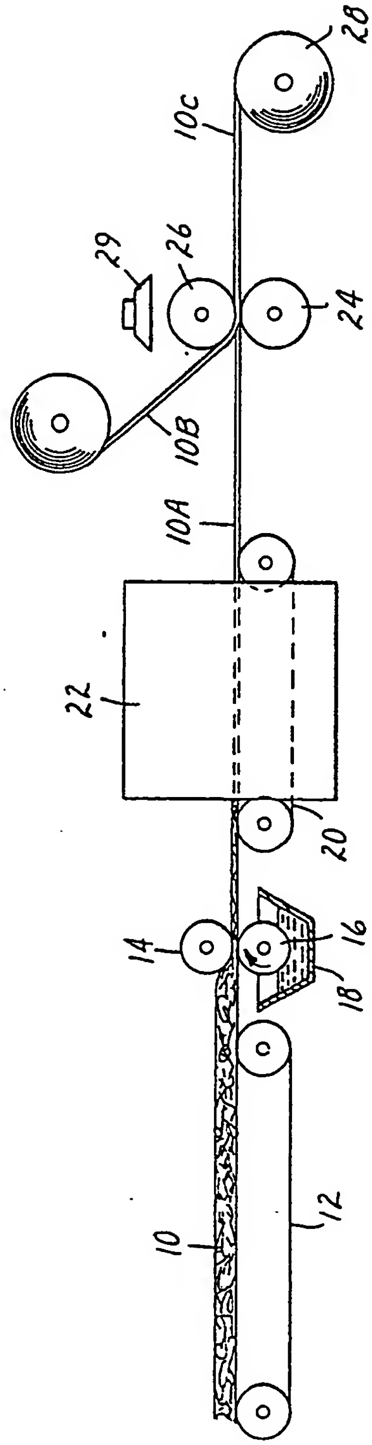

FIG. 1

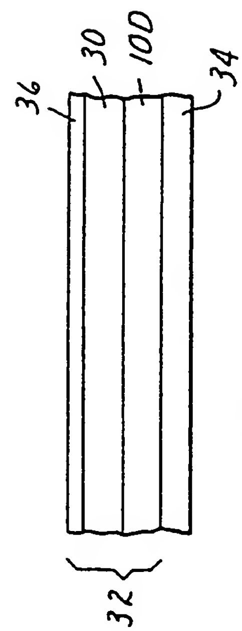

FIG. 2

INTERNATIONAL SEARCH REPORT

International Application No PCT/US80/01152

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

I PC$C09J 7/02

U.S. 428-284

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
U. S.	156/166, 280 427/121,208.4,208.8,365,366,369,370,401,412 428/284,286,287,290,293,294,302,303,354

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
A	U.S,A,2,548,980, Published 17 April 1951	
A	U.S,A,2,733,169, Published 31 January 1956	
A	U.S,A,2,750,314, Published 12 June 1956	
A	U.S,A,2,750,315, Published 12 June 1956	
A	U.S,A,2,753,285, Published 03 July 1956	
X	U.S,A,3,027,279, Published 27 March 1962 See col. 5, lines 17-60	1-9
X	U.S,A,3,309,260, Published 14 March 1967 See col. 1, lines 14-57; col. 2, lines 24-35; and col. 4, lines 64-75	1-9
A	U.S,A,3,562,088, Published 09 February 1971	
A	U.S,A,3,716,437, Published 13 February 1973	
A	U.S,A,3,718,495, Published 27 February 1973	
X	U.S,A,4,035,694, Published 12 July 1977 See col. 4, lines 11-28 and col. 4, line 41-col. 5, line 17	1-9

* Special categories of cited documents: [15]

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"X" document of particular relevance

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
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